The Office of Environment, Safety and Health and its Office of Nuclear and Facility Safety (NFS) publishes the Operating Experience Weekly Summary to promote safety throughout the Department of Energy (DOE) complex by encouraging feedback of operating experience and encouraging the exchange of information among DOE nuclear facilities.

The Weekly Summary should be processed as an external source of lessons-learned information as described in DOE-STD-7501-96, *Development of DOE Lessons Learned Programs*.

To issue the Weekly Summary in a timely manner, the Office of Operating Experience Analysis and Feedback (OEAF) relies on preliminary information such as daily operations reports, notification reports, and, time permitting, conversations with cognizant facility or DOE field office staff. If you have additional pertinent information or identify inaccurate statements in the summary, please bring this to the attention of Dick Trevillian, 301-903-3074, or Internet address dick.trevillian@hq.doe.gov, so we may issue a correction.

Readers are cautioned that review of the Weekly Summary should not be a substitute for a thorough review of the interim and final occurrence reports.

Operating Experience Weekly Summary 97-07

February 7 through February 13, 1997

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EVENTS

1. CRITICALITY ACCIDENT ALARM SYSTEM AUDIBILITY PROBLEMS

Operating Experience Analysis and Feedback engineers reviewed two occurrence reports this week where criticality accident alarms could not be heard at the Oak Ridge Y-12 Site. In the first occurrence, personnel conducting a quarterly surveillance test were concerned that a clarion horn could not be heard above operating equipment noise. This resulted in an unreviewed safety question determination. In the second occurrence, a relay failure prevented operation of emergency notification system speakers during a monthly surveillance test. These events are significant because the ability to detect a criticality and alert personnel is important for personnel safety. Audible alarms alert personnel to evacuate areas during an emergency. Evacuation is an effective way of reducing exposure to ionizing radiation by employing distance or physical barriers. (ORPS Reports ORO--LMES-Y12SITE-1997-0008 and ORO--LMES-Y12SITE-1997-0009)

On January 25, 1997, during a quarterly test of a building criticality accident alarm system, testers raised the concern that the audible signal could not be heard during periods when processing equipment was operating. They tested the alarm system when no processing equipment was operating, and the clarion horn sound level of 98 decibels could be heard in all facility areas. They determined normal ambient background noise level was less than 75 decibels. However, when the facility was in full operation (background noise level 98 decibels), the audible signal potentially could not be heard. The testers also determined that the single magenta warning light in the area provided less than adequate visual coverage.

The area of concern is confined to a single, high-noise piece of equipment in a room that is not normally accessed, except by the equipment operators. Investigators learned that the equipment is a new model, and its installation changed the baseline noise data for the area. The facility manager required operators to post the area to prevent access when equipment is operating unless operators are wearing alarming radiation detection devices with visual alarm capability. A preliminary assessment by engineers also indicated a need for eight additional magenta warning lights.

On February 8, 1997, during a monthly surveillance of the criticality accident alarm system in another building, a shift manager noticed that an emergency notification speaker in her office was not transmitting chimes even though the public address system speaker activated. The shift manager notified test personnel, and they determined that none of the facility emergency notification speakers chimed during testing. Maintenance technicians found a bent pin on a relay for the alarms. They straightened the pin, replaced the relay, and re-tested the system satisfactorily.

Investigators have not determined how or when the relay pin was bent. The facility manager notified other facility managers of this discovery. In addition, the criticality accident alarm system manager is reviewing design documentation to determine if the relay was identified as a single-point-failure component. He is also considering increasing the number of participants in the monthly surveillance to help identify similar equipment failures in the future.

NFS reported inaudibility of criticality accident alarm system events in Weekly Summaries 96-27, 96-24, 96-20, and 96-04. Weekly Summary 96-20 described a similar event at the Y-12 Site. On May 10, 1996, the Disassembly and Storage Organization facility manager at the Y-12 Site reported that safety engineers determined an unreviewed safety question existed regarding inaudibility of criticality accident alarm systems in utililty rooms containing air handling units. Because of a high noise level inside the units when the fans were running, personnel could not hear criticality accident alarms or other emergency notifications. Investigators determined that the direct cause was inadequate or defective design because system design features had not received adequate consideration with respect to audibility in the required 200-foot coverage zone. (ORPS Report ORO--LMES-Y12SITE-1996-0020)

Operating Experience and Analysis Engineers found that inadequate and defective design contributed to 46 percent of the root causes for criticality alarm audibility problems reported DOE-wide in the Occurrence Reporting and Processing System. Inadequate administrative controls and defective or failed parts were the root causes in 20 percent of the reports.

These events highlight the importance of properly testing and maintaining criticality accident alarm systems. Baseline noise-level data should be recorded, maintained, and updated to reflect equipment or facility modifications that could affect the audibility of existing alarm systems. Changing operating conditions or modes can affect background noise levels. In the second event, an alert shift manager identified a speaker deficiency during a monthly test that would not have been found until performance of the quarterly test.

ANSI/ANS-8.3, *Criticality Accident Alarm System*, provides direction for establishing and maintaining an alarm system. Section 4.4.1 requires quarterly checks of audible alarms in areas that may require personnel evacuation. The standard states that alarms are for immediate evacuation and shall be of sufficient volume and coverage to be heard in all areas to be evacuated. Section 4.4.3 requires that the signal generator produce an overall sound pressure level that is not less than 10 decibels above the maximum typical ambient noise level and, in any case, not less than 75 decibels at any location requiring immediate evacuation. Section 4.4.11 states that areas with very high background noise may also require use of visual signals.

KEYWORDS: criticality alarm, criticality safety, surveillance, test

FUNCTIONAL AREAS: nuclear/criticality safety, surveillance

2. UNDERWATER TOOL CONTACTS ENERGIZED RACEWAY

On February 6, 1997, at the Savannah River Receiving Basins for Offsite Fuels, operators contacted an energized overhead monorail raceway with a metal, 34-foot-long underwater tool and tripped a breaker supplying gamma radiation monitors. The operators were using the tool to ensure proper spacing of fuel racks. As they removed it from the water, the tool shifted unexpectedly, and the top contacted the raceway. No one was injured. Investigators determined that inattention by the operators caused this event. Lack of attention to detail created the potential for injury and equipment damage. (ORPS Report SR-WSRC-RBOF-1997-0002)

Construction personnel were installing new fuel racks and had determined they could not use the tool normally used for spacing verification between the racks because of the sloping basin floor. Engineering, quality control, and operations personnel determined they could use a smaller diameter, but longer basin tool to ensure that minimum spacing requirements were met. The basin tool had an L-bracket attached to one end that had to be removed before use. Operators were withdrawing the tool from the repackaging basin to remove the L-hook when the end contacted the energized raceway bus bar.

The facility manager conducted a critique of the event and identified the following corrective actions.

- Engineering will evaluate installing ground fault interrupt breakers on the monorail power supply and de-energizing the electrical section of the monorail raceways when not in use.

- Electrical mechanics will inspect the raceway covers and guards for damage. They will also install warning signs on the energized raceways.

- Management staff will review the adequacy of the training on the monorail system.

- Engineering will evaluate the use of a non-conductive pole material for basin operations.

- Operations manager will inspect the basin area to determine if other potential overhead hazards exist and will identify areas where tools can be safely removed from the basins.

NFS reported events caused by inattention to detail in 13 Weekly Summaries in 1996. Examples include leaving a diesel generator mechanical transfer switch in the wrong position; lifting and taping the wrong leads and verifying them as correct; removing an area radiation monitor for calibration and then removing the wrong radiation probe, and failing to re-install motor hold-down bolts after maintenance, failure to weld steam pipe anchors, and perform prerequisite lockout/tagout or zero energy checks.

Operating Experience Analysis and Feedback (OEAF) engineers reviewed the Occurrence Reporting and Processing System (ORPS) database for inattention to detail events DOE-wide for the dates February 1, 1996, through February 1, 1997, and found 555 events. Facility managers reported that personnel errors and management problems have been the root causes for the majority of these events. Figure 2-1 shows the distribution of these root causes.

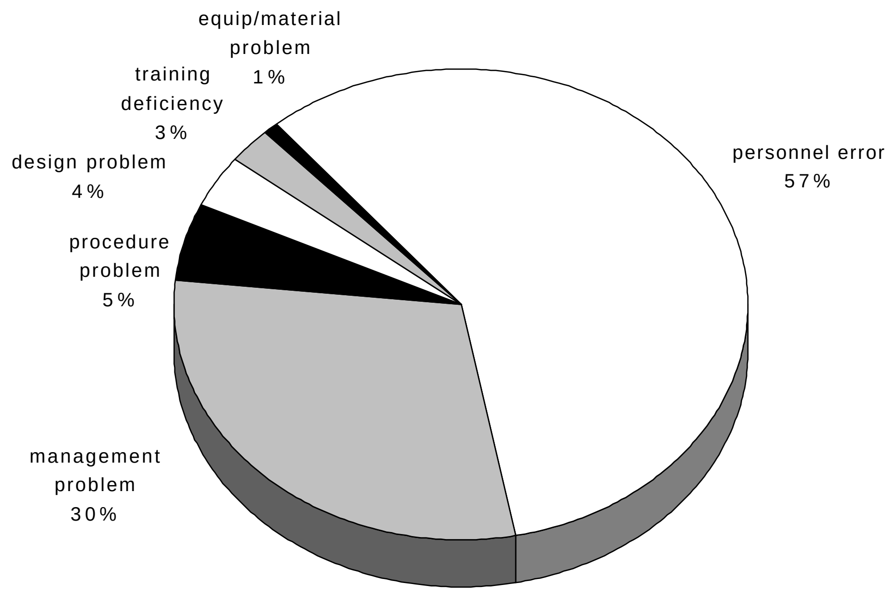

Figure 2-1. Distribution of Root Causes of Inattention To Detail Events[1]

OEAF engineers also reviewed the causal factors for the root causes and determined that inattention to detail was the major contributor for personnel error, accounting for 82 percent. Table 2-1 shows the breakdown of the causal codes by percentage of each major area.

Table 2-1. CONTRIBUTION OF INATTENTION TO DETAIL EVENTS BY CAUSAL CODES

Personnel Error	**Percentage**
Inattention to detail	82
Procedure not used or used incorrectly	11
Other human error	4
Communication problem	3
Management Problem	
Inadequate administrative control	32
Policy not adequately defined, disseminated, or enforced	26
Work organization/Work planning	20
Other management problem	13
Inadequate supervision	7
Improper resource allocation	2

[1] OEAF engineers screened the ORPS database for Direct Cause "03A" (inattention to detail) for Final Report dates 02/01/96 through 02/01/97 and found 555 events.

This event underscores the importance of attention to detail, conducting a review of the hazards in the work area, and providing barriers to prevent personal injuries or equipment damage. NFS advocates self-checking, a risk management tool designed to reduce the potential for human error. Self-checking requires distinct thoughts and actions that focus attention at a specific moment before performing a task. DOE/EH-0502, Safety Notice 95-02, "Independent Verification and Self-Checking," describes a technique that requires workers to (1) stop before performing the task to eliminate distractions and identify the correct component; (2) think about the task, expected response, and actions required if that response does not occur; (3) reconfirm the correct component and perform the function; and (4) review by comparing the actual versus the expected response. Human actions can be considered a barrier to provide controls over hazards associated with a job. OEAF developed a *Hazard and Barrier Analysis Guidance Document* that provides a set of straightforward tools to devise more effective strategies for preventing and evaluating accidents and accident precursors across the DOE complex. A copy is available from Richard Trevillian, (301) 903-3074. Managers and supervisors should review the guide and incorporate hazard and barrier analyses into work and operation processes.

KEYWORDS: electrical hazard, inattention to detail, hazard analysis

FUNCTIONAL AREAS: industrial safety, operations

3. VIOLATION OF A CRITICALITY SAFETY SPECIFICATION ADMINISTRATIVE CONTROL

On February 4, 1996, the Pacific Northwest National Laboratory (PNNL) reported a violation of a criticality safety specification for special reflectors (natural uranium, depleted uranium, and thorium). Two staff members identified the potential violation of a criticality safety specification during a fissionable material handler retraining class. During a classroom review of the criticality safety specification, the staff members advised the instructor, a senior engineer for criticality safety, that a location in each of their work areas could be inconsistent with a footnote on special reflectors. The instructor contacted the senior specialist for criticality safety analysis, who determined that the footnote applied to the conditions identified by the two staff members. A team of PNNL criticality safety experts evaluated the incident and found that storage conditions in the two rooms violated criticality safety specification administrative controls. Investigators determined that staff members were aware of the footnote in the criticality safety specification but had not considered its applicability to their tasks. Failure to follow the requirements of the footnote resulted in the criticality safety specification violation. (ORPS Report RL--PNNL-PNNLNUCL-1997-0002)

The senior specialist determined that one of the rooms contained fissionable material stored within 12 inches of kilogram quantities of depleted and natural uranium; the other room contained material stored within 12 inches of kilogram quantities of thorium and natural uranium. The criticality safety experts confirmed a violation of the criticality safety specification administrative control existed in both rooms. They also determined that the criticality safety analysis group had not completed a safety analysis review for the spacing of the fissionable material and the special reflectors. An evaluation team developed a recovery plan and moved the reflectors from the proximity of the fissionable material. The PNNL senior engineer for nuclear safety is inspecting other laboratory areas to ensure there are no other infractions.

NFS reported criticality safety infractions in 17 Weekly Summaries in 1996.

- Weekly Summary 96-49 reported on two events at the Rocky Flats Environmental Technology Site where failure to comply with administrative controls could have lowered criticality safety margins. On December 2, 1996, during a routine tour, a shift manager noticed someone had moved two material transfer carts containing materials that were restricted from movement because of a criticality safety concern. On November 26, 1996, contractor personnel moved six drums between two buildings, violating movement restrictions that were posted on a storage vault door. Movement of the drums violated the compensatory measures for an unreviewed safety question because of the content of nearby drums. The shift manager terminated all nuclear operations. (ORPS Report RFO--KHLL-SOLIDWST-1996-0160 and RFO--KHLL-PUFAB-1996-0138)

- Weekly Summary 96-13 reported that on March 20, 1996, at the Hanford Plutonium Finishing Plant, a process operator placed two containers of plutonium within 10 inches of a furnace. A third container of plutonium was already located inside a furnace, thus creating a criticality prevention specification infraction. Facility personnel wrote a recovery plan and moved the two containers away from the furnace. (ORPS Report RL--WHC-PFP-1996-0015)

Operating Experience Analysis and Feedback (OEAF) engineers reviewed the Occurrence Reporting and Processing System (ORPS) database for nuclear criticality safety violations and found 492 events. Figure 3-1 depicts the distribution of root causes of these events.

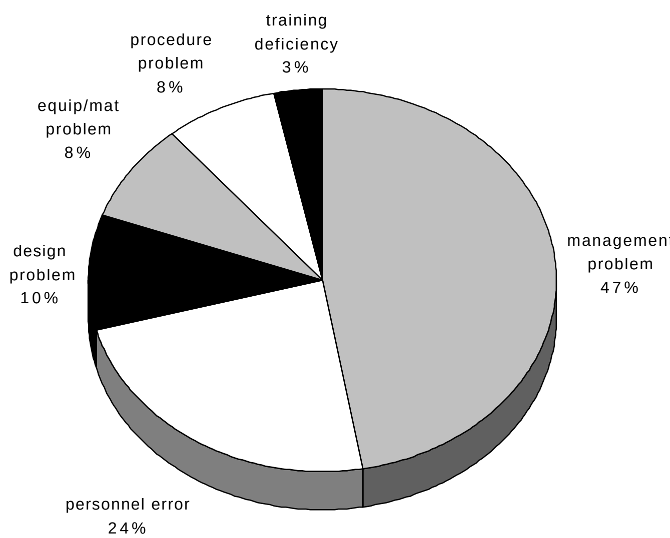

Figure 3-1. Distribution of Root Causes of Nuclear Criticality Safety Events[1]

[1] OEAF engineers screened the ORPS database for Nature of Occurrence “01A@” (nuclear criticality safety) and found 492 events DOE-wide.

Management problems and personnel errors were the major contributors to nuclear criticality safety violations throughout the DOE complex. Table 3-1 shows the breakdown of causal code by percentage for the major areas.

TABLE 3-1. CONTRIBUTION TO NUCLEAR CRITICALITY SAFETY EVENTS BY CAUSAL CODES

Management Problem	**Percentage**
Inadequate administrative control	42
Policy not adequately defined, disseminated, or enforced	24
Other management problem	22
Work organization/Work planning	11
Inadequate supervision	2
Personnel Error	
Inattention to detail	51
Procedure not used or used incorrectly	31
Other human error	14
Communication problem	4

These events illustrate the potential consequences of the lack of administrative or procedural controls. When working with criticality safety issues, these controls must be explicit and easily understood. Personnel working with fissile materials need to be aware of their actions when storing and moving these materials. DOE-STD-1029-92, *DOE Writer's Guide for Technical Procedures,* establishes the recommended process for developing technical procedures that are accurate, complete, clear, and consistent. The guide provides guidance for developing a procedure basis; planning, organizing, and structuring the procedure; developing content and establishing format; and writing action steps. DOE and facility managers should review their procedures to ensure they meet the requirements of this standard.

KEYWORDS: criticality, inattention to detail, procedure, storage

FUNCTIONAL AREAS: nuclear/criticality safety, procedures

4. UNAUTHORIZED STORAGE AND HANDLING OF EXPLOSIVES

On February 3, 1997, at Lawrence Livermore National Laboratory, a chemistry and materials science technician removed surplus chemicals from a chemical storeroom to have them evaluated for re-use or disposal by a waste technician. A small vial labeled as containing 100 mg of powdered explosives was included with the surplus chemicals. The waste technician saw the vial was labeled as explosive and told the chemistry and materials technician he could not handle it. The next morning, the chemistry and materials science technician, who was not a trained explosives handler, carried the vials into an office and asked a health and safety technician for guidance. The quantity of explosives exceeded the 10-mg explosives safety limit for the building. (ORPS Report SAN--LLNL-LLNL-1997-0007)

The health and safety technician read the label on the vial, called an explosives safety engineer, and secured the vial in his office. When the explosives safety engineer arrived, he confirmed the vial was labeled as containing 0.1 grams (100 mg) of RDX (cyclotrimethylene trinitramine) explosive. The engineer and technician notified the Chemistry and Materials Science Assurance Office that the quantity of explosives exceeded the 10-mg limit for handling and storing as non-explosives. The explosives safety engineer (a qualified explosives handler) placed the vial inside an explosives storage container and temporarily locked it in a formerly authorized explosives storage/handling area. Another qualified explosives handler later transported the container to an authorized explosives handling and storage room in another building, where he weighed the explosives and determined the vial contained 87.6 mg of RDX.

Investigators later determined that the explosive material was in a stable condition. The maximum possible energy release from this quantity of explosives is equivalent to a small fire cracker. Further investigation to determine root cause and corrective actions will be completed as part of the normal occurrence reporting process.

NFS has reported explosives storage and handling events in Weekly Summaries 96-18, 95-29, and 95-19 and improper storage of hazardous chemicals in Weekly Summaries 97-04, 96-39, 96-23, and 92-16.

- On July 12, 1995, at the Mound Plant, a DOE inspector discovered three explosive components in a non-explosive area. The components were inside a cardboard box wrapped in foam material. The box was not identified as containing explosives. Qualified explosives workers placed the components in a proper shipping container and marked them appropriately. Mound managers determined that this event was caused by an employee who failed to recognize the explosive components. (Weekly Summary 95-29, ORPS Report OH-MB-EGGM-EGGMAT03-1005-0005)

- On September 17, 1996, at the Savannah River Site, a laboratory technician found a bottle containing 8 ounces of picric acid that had crystallized. When crystals form in picric acid there is a strong potential for an explosion hazard. Law enforcement officers took the acid to a safe locations and detonated it. (Weekly Summary 96-39, ORPS Report SR--WSRC-LTA-1996-0033)

This event underscores the importance of reviewing and reducing chemical and hazardous material inventories to required and manageable levels. In order to safely accomplish this, personnel should be trained in identification, handling, and storage requirements for hazardous materials. When inventories of stored chemicals are suspect, past facility operations and missions should be considered before personnel attempt to locate and move legacy materials that could have become unstable or unsafe. It may become necessary for experienced personnel and subject matter experts, such as explosives handlers, to assist in these efforts from the outset. Personnel should also consider the type and quantity for materials they have before moving them to another location where storage and handling limits could be exceeded.

Initiation of even small amounts of explosives can result in personnel injury. Larger explosions could affect other explosives or hazardous materials in the immediate area, resulting in a more serious accident. DOE M 440.1, *DOE Explosives Safety Manual,* prescribes safety procedures for handling explosives and provides guidance and requirements for storage. Chapter II, "Operational Safety," provides guidance on transportation and storage of explosives. Chapter V, "Training," provides guidance and requirements for the training of explosives workers, including training on hazardous materials in general. Hazardous materials training should include labeling systems and material data sheet terms; proper use of engineering controls and protective equipment; and preparation for unexpected hazardous conditions.

KEYWORDS: explosives, storage, chemical

FUNCTIONAL AREAS: explosives safety, chemical safety

5. SPARK IGNITES DEPLETED URANIUM FILINGS IN MACHINE SHOP

On February 6, 1997, at Lawrence Livermore National Laboratory, a pile of depleted uranium chips ignited when a machine shop operator created a spark with a hand file as he removed a burr on a depleted uranium part. The fire was contained within a bandsaw enclosure that is supplied with negative ventilation and a HEPA filter for radioactive materials. When they saw the fire, other personnel in the area evacuated and notified the fire department. The operator used an extinguisher to contain the fire until the fire fighters in self-contained breathing apparatus and protective clothing extinguished the fire. The operator and two fire fighters received contamination to their clothing. Cleanup of filings and chips of pyrophoric metals is important in preventing fire hazards that can result in personnel contamination, injury, and equipment damage. (ORPS Report SAN--LLNL-LLNL-1997-0010)

When the fire started, the operator immediately grabbed a fire extinguisher containing Met-L-X™ fire extinguishing agent and tried to contain the fire until the fire fighters arrived. Health and safety technicians monitored evacuees for contamination and determined no one was contaminated. The technicians surveyed the operator and detected contamination reading 200 cpm in his hair and 100 cpm on his shoes. They also surveyed the fire fighter's clothing and detected contamination reading from 200 cpm to 600 cpm. Medical personnel decontaminated the operator at the Medical Facility and performed precautionary lung scans and a urine analysis on him and seven other people who were in the area at the time of the fire.

Investigators are examining the enclosure to determine the extent of the damage. Health and safety technicians surveyed the exhaust for contamination; none was detected. Investigators determined that depleted uranium chips from the operation of the bandsaw contributed to the fire.

NFS reported events where fillings and chips from the machining of pyrophoric metals caught fire in Weekly Summaries 96-05 and 94-35.

- On January 26, 1996, at Sandia National Laboratory, an operator was machining a block of magnesium when a hot metal chip ignited magnesium chips that had accumulated at the end of the machine table. Heat from the fire actuated an overhead sprinkler. The fire burned itself out before extinguishing agents could be applied, and there were no injuries. Investigators determined the machinist had been in a 5-year apprenticeship training program, but there was no documention for refresher training on pyrophoric materials. (Weekly Summary 96-05; ORPS Report ALO-KO-SNL-1000-1996-0001)

- On August 23, 1994, at Lawrence Livermore National Laboratory, an operator started a bandsaw while the blade was in contact with a block of depleted uranium. The cutting action generated a spark that ignited depleted uranium chips that had accumulated on a wire brush positioned against the blade for chip removal. The resulting flame ignited the V-belt that drove the wire brush. The operator extinguished the fire with a fire extinguisher. There was no exposure to the operator and no spread of contamination. The operator's inattention to detail was the direct cause of the event. A lesson learned from this event was that operators need to be more attentive to machine set-ups and housekeeping. (Weekly Summary 94-35; ORPS Report SAN--LLNL-LLNL-1994-0061)

Operating Experience Analysis and Feedback engineers reviewed the Occurrence Reporting and Processing System database for all reports involving cutting and machining of metals that resulted in fires and found 8 events DOE-wide. Defective or failed material and defective or inadequate procedure contributed to 58 percent of the direct causes reported by facility managers. The remaining 42 percent was evenly divided among insufficient refresher training, inattention to detail, and inadequate management control.

DOE-HDBK-1081-94, *Primer on Spontaneous Heating and Pyrophoricity*, provides information on properties; storage and handling; process hazards; and fire extinguishing methods for combustible metals. Most metallic uranium in massive forms does not present a significant fire risk unless exposed to a severe and prolonged external fire. Once ignited, massive metal burns very slowly. However, uranium in finely divided form is readily ignitable, and uranium scrap from machining operations is subject to spontaneous ignition. Grinding dust has been known to ignite even under water. The pyrophoric characteristics of uranium are similar to those of plutonium, except uranium forms do not ignite as easily. Uranium fires should not be approached without protective clothing and respirators unless the fire is in a glovebox. The handbook recommends covering the fire with magnesium oxide sand or flooding with argon. Typical foam or dry chemical agents are not effective. Using water to extinguish the fire is acceptable if criticality safety considerations are not necessary. Proper housekeeping (removal of combustible forms of uranium) is the most important aspect of minimizing fire loss.

KEYWORDS: pyrophoric, uranium, metal, fire

FUNCTIONAL AREAS: fire protection

OEAF ACTIVITY

Operating Experience Analysis and Feedback (OEAF) Engineers reviewed two recent events involving violations of nuclear material storage limits. As a result of this review, They performed a detailed analysis of nuclear material storage violations across the DOE complex. The results of this analysis are included in the following article.

1. ANALYSIS OF NUCLEAR MATERIAL INVENTORY STORAGE VIOLATIONS

Event Description

Operating Experience Analysis and Feedback (OEAF) engineers recently reviewed a January 16, 1997, Fernald event and a January 17, 1997, Hanford event related to storage of nuclear material in excess of hazard category limits. In both cases, managers at the facilities were unaware that the buildings with the excess fissile material were subject to DOE requirements for nuclear material storage. Because engineers had not performed specific nuclear safety analyses for the buildings, the structures were bound by the storage limits in DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*. At Fernald, workers moved slightly enriched uranium into a storage building, violating nuclear material mass limits, because managers at the building did not know the storage limits specified in the standard. At Hanford, depleted uranium had been stored in a warehouse since 1987. Managers with knowledge of the specific quantity of material being stored were not aware of the specific hazard Category 3 limits contained in the standard. Engineers who had knowledge of the limits in the standard were unaware of the quantity being stored. Noncompliances with the storage limits specified in DOE-STD-1027-92, without other specific safety analyses, are violations of the authorization basis and may be unreviewed safety questions.

On January 16, 1997, at Fernald, the facility manager reported that the nuclear material mass limit was violated in a storage building categorized as non-nuclear. In late 1996, workers moved slightly enriched uranium from another building to the storage building. They moved the uranium to allow storage of flammable waste in the first building because it had a fire suppression system. Moving additional nuclear material to the storage building resulted in exceeding the limits listed in the standard. An engineer familiar with the limits in the standard discovered the problem when he reviewed the nuclear material inventory database for the facility. Engineers categorized the nuclear hazard in the building and performed a nuclear safety analysis in accordance with DOE Order 5480.23, *Nuclear Safety Analysis Reports*. They determined that excess material in the building did not lower the facility margin of safety. (OH-FN-FDF-FEMP-1997-0006)

On January 17, 1997, investigators at the Hanford Fast Flux Test Facility determined that a warehouse contained nuclear material in excess of DOE-STD-1027-92 limits. Facility personnel conducted an inventory check of depleted uranium in the building after reviewing a report in Weekly Summary 96-50 involving a violation of the standard at the Pantex Plant (ALO-AO-MHSM-PANTEX-1996-0235). Engineers have prepared a Justification For Continued Operation until the final disposition of the depleted uranium can be determined. (RL--PHMC-400NE-1997-0001)

Background

DOE Order 5480.23 requires contractors to analyze and categorize hazards at their facilities. The Order identifies three levels of hazards.

- Category 1 — The hazard analysis shows the potential for significant off-site consequences.
- Category 2 — The hazard analysis shows the potential for significant on-site consequences.
- Category 3 — The hazard analysis shows the potential for only significant localized consequences.

The Order provides for a graded approach in which the level of effort to protect the facility is proportional to the complexity of facility and the safety systems relied on to maintain an acceptable level of risk.

DOE-STD-1027-92 provides guidance for determining the hazard category of a facility. Attachment 1 of the standard provides threshold values for various radionuclides. If the quantity of material (in curies or grams) exceeds the threshold value, the facility should be categorized at the next highest level. Facilities that meet or exceed Category 3 thresholds must comply with DOE 5480.23. A facility that does not meet the Category 3 threshold limit, but still contains radioactive material, may be considered a radiological facility. The radionuclides allowed in a hazard Category 3 facility are based on 40 CFR 302.4, Appendix B. The allowable quantities of radionuclides, if released, would produce less than 10 rem doses at 30 meters from the release, based on a 24-hour exposure.

Concerns

The Office of Nuclear and Facility Safety has learned that the storage limits for calculated depleted uranium for Category 3 facilities may be incorrectly calculated for some facilities. DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, states that the activity limit for U-238 is 4.2 curies or 13,000 kilograms. The activity limit for U-233, U-234, and U-235 is also 4.2 curies; but, because of the higher activity of these isotopes, the allowable mass storage limits are lower. Depleted uranium typically contains 0.2 percent weight U-235 and 0.0015 percent weight U-234. This mixture has a specific activity of 4×10^{-7} curies/gram and the allowable Category 3 threshold limit is approximately 10,000 kilograms. Table 1-1 (extracted from Attachment 1 of the standard) shows the Category 3 limits for uranium isotopes in both curies and grams.

TABLE 1-1. DOE-STD-1027-92 THRESHOLD LIMITS FOR URANIUM ISOTOPES

Isotopes	Category 3 (Curies)	Threshold (Grams)
U-233	4.2E+00	4.4E+02
U-234	4.2E+00	6.7E+02
U-235	4.2E+00	1.9E+06
U-238	4.2E+00	1.3E+07

Analysis

OEAF engineers reviewed the Occurrence Reporting and Processing System (ORPS) database for nuclear material inventory storage violations and found 130 events DOE-wide. Events reviewed included all violations related to nuclear material inventory, not just those related to DOE-STD-1027-92 or DOE Order 5480.23. Some of the more common issues reported in ORPS included the following.

- failure to realize that a facility had nuclear material storage limits
- quantity of material in a facility was within limits, but quantity of material in individual containers exceeded limits
- type of container not approved for storage of material
- failure to follow postings regarding limits when placing material in an area
- failure to properly assess or label quantity of material in containers prior to moving
- failure to properly evaluate work or receive authorization for a job prior to starting task
- discovery of legacy nuclear material
- failure to properly follow procedure

An analysis of the results of the ORPS search indicates there has been an increase in these types of violations from 1991 to 1996. Figure 1-1 shows the trend of the violations.

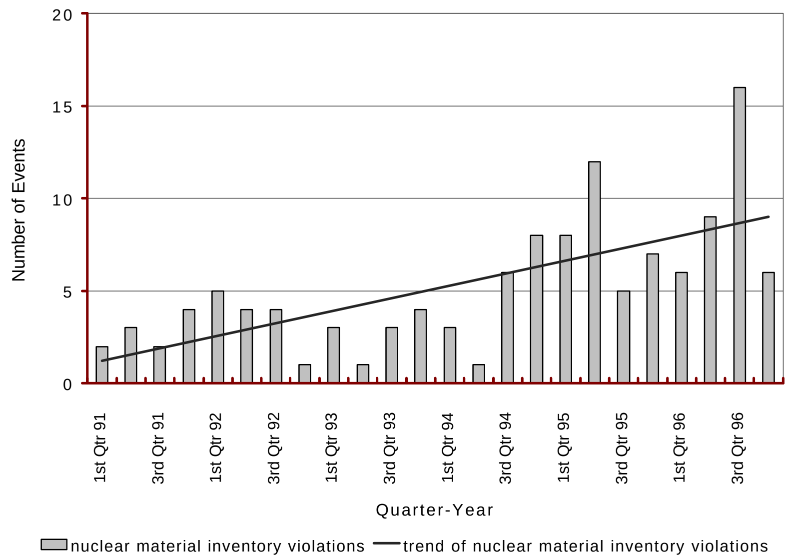

Figure 1-1. Trend of Nuclear Inventory Violations 1991-1996[1]

An analysis of these events indicates that 49 percent had a direct cause of personnel error. The second highest causal factor was management deficiencies, which was reported as the direct cause in 28 percent of the events. A distribution of the direct causes is shown in figure 1-2.

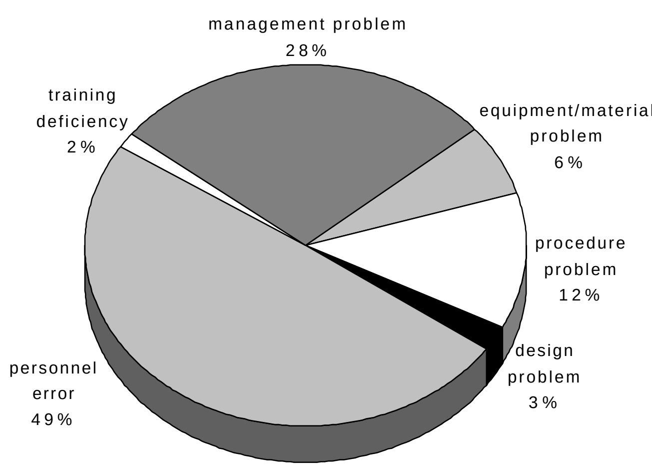

Figure 1-2. Direct Causes for Nuclear Material Inventory Storage Violations[2]

[1] OEAF engineers reviewed the ORPS database for the 6 years 1991 through 1996, all narrative, (kilogram@ OR gram@ OR millicurie@ OR curie@) AND (fissile OR special OR snm@ OR radionuclide@ OR nuclear) AND (infract@ OR violat@ OR exec@ OR compl@ OR limit@ OR inventor@) AND (order@ OR stand@ OR tsr OR osr OR proced@ OR admin@ OR require@ OR control@) AND (AND NOT alarm@ AND NOT fuel@ AND NOT contamin@ AND NOT expos@ AND NOT explosi@ AND NOT dose@ AND NOT calibrat@) AND nature of occurrence code 1@ OR 5J OR 7@ OR 9 OR 10 and found 123 occurrences. Based on a random sample of 30 reports, OEAF engineers determined that each slice is accurate within ± 3.0 percent.

Almost 50 percent of the violations had a direct cause of personnel error. An analysis of the root causes for these personnel errors shows that inattention to detail accounts for over one third of the events. Two management issues, inadequate administrative control and inadequate communication of policy, comprised 40 percent of the personnel errors. Only 4 percent of the cases were attributed to lack of training or insufficient experience. Table 1-2 shows the root causes for events with the direct cause code of personnel error.

TABLE 1-2. DISTRIBUTION OF ROOT CAUSES OF PERSONNEL ERRORS

Cause Code	Percent
Inattention to detail	36
Inadequate administrative control	30
Policy not adequately defined, disseminated, or enforced	10
Defective or inadequate procedure	7
Other human error	5
Procedure not used or used incorrectly	3
Work organization/planning deficiency	3
Inadequate work environment	2
Insufficient practice or hands-on experience	2
No training provided	2

Failures such as human performance errors or inadequate management controls are also representative of failed barriers. According to the OEAF *Hazard and Barrier Analysis Guide*, barriers provide controls over hazards associated with a job. Barriers may be physical barriers, procedural or administrative barriers, or human action. Barriers can be imposed in parallel to provide defense-in-depth and to increase the margin of safety. The reliability of barriers is important in preventing undesirable events. The reliability of a barrier is determined by its ability to resist failure. Managers with limited resources should determine the most reliable barriers available to ensure the highest margin of safety. The *Hazard and Barrier Analysis Guide* provides a detailed analysis for selecting optimum barriers, including a matrix that displays the effectiveness of different barriers in protecting against some common hazards. Figure 1-3 shows how breached barriers can fail to protect against unsafe events.

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[2] OEAF engineers reviewed the ORPS database for all narrative, (kilogram@ OR gram@ OR millicurie@ OR curie@) AND (fissile OR special OR snm@ OR radionuclide@ OR nuclear) AND (infract@ OR violat@ OR exec@ OR compl@ OR limit@ OR inventor@) AND (order@ OR stand@ OR tsr OR osr OR proced@ OR admin@ OR require@ OR control@) AND (AND NOT alarm@ AND NOT fuel@ AND NOT contamin@ AND NOT expos@ AND NOT explosi@ AND NOT dose@ AND NOT calibrat@) AND nature of occurrence code 1@ OR 5J OR 7@ OR 9 OR 10 and found 130 occurrences. Facility Managers determined direct causes in 124 of the events; 61 events had personnel error as the direct cause. Based on a random sample of 30 reports, OEAF engineers determined that each slice is accurate within ± 2.7 percent.

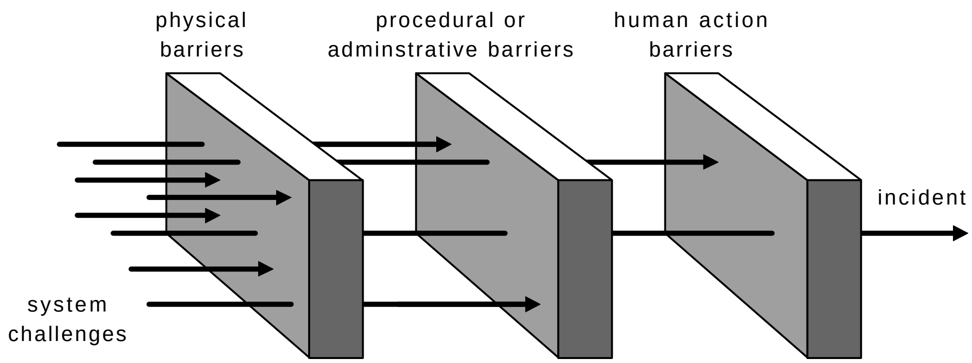

Figure 1-3. Breached Barriers Allow Event to Occur

Because each barrier shown in the example figure has a reliability factor of 50 percent, placing the barriers in parallel would increase the margin of safety to 87.5 percent. Managers can increase the margin of safety by using more barriers as well as more reliable barriers.

Conclusions

Although nuclear material inventory violations have increased since 1991, the trend may be related to changing missions of facilities and additional storage of radionuclides rather than increased weaknesses in storage programs. In some cases, events were caused by changing requirements, such as the issuance of DOE-STD-1027-92. In other cases, the changing mission of the facility allowed for less nuclear material to be stored, contributing to the violation.

Facility managers identified training as the direct cause in only 2 percent of these events and as the root cause in only 2 percent of the personnel error events. However, OEAF engineers determined that the majority of occurrence reports list additional training as one of the corrective actions. This suggests that training is under-reported as a cause, and enhanced training could make human actions a more reliable barrier.

Recommendations

The following recommendations may serve as effective barriers against nuclear material inventory violations. OEAF engineers extracted these recommendations from the lessons-learned and corrective actions listed in the occurrence reports related to these types of events. Managers responsible for storage and handling of nuclear materials should review their programs to determine if these recommendations need to be incorporated. These recommendations should be processed as an external source of lessons-learned information as described in DOE-STD-7501-96, *Development of Lessons Learned Programs.*

1. Inventory actual amounts of nuclear material at storage locations and compare results with existing tracking systems (lists, databases, etc.) for these locations.

2. Develop a system to ensure that changes to inventories are correctly reflected in tracking systems. This includes ensuring that work requests and work packages contain provisions to update tracking systems.

3. Establish a program to periodically inspect nuclear material to ensure that the inventory and configurations have not changed.

4. Establish exact requirements for storage of nuclear material. Disseminate this information to the custodians of the material.

5. Ensure cross-communication between work groups. Groups that are responsible for inventory requirements need to communicate with groups that oversee the material.

6. Ensure that requirements are properly reflected in facility basis documents and procedures.

7. Ensure that the program to revise basis documents and procedures is rigorous and systematic to ensure all changes to requirements and inventories are captured in revisions to procedures.

8. Ensure that material inventory requirements are considered when developing work requests and work packages and are discussed in job briefings and planning meetings.

9. Ensure that implementing procedures are clearly written and contain a level of detail commensurate with the task to be performed. Difficult and infrequently performed evolutions require additional detail.

10. Use worker aids, such as placards and postings, to remind workers of the proper way to perform the job. Ensure the placards and postings are readily visible and near the work site.

11. Ensure that workers are properly trained on material inventory requirements.

12. Ensure that lessons learned from previous events are disseminated to all appropriate employees.

13. Develop a culture among employees that allows them to have a questioning attitude toward work and unusual conditions.

References

1. DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, December 1992.

2. DOE-STD-7501-96, *Development of Lessons Learned Programs*, May 1995.

3. DOE Order 5480.23, *Nuclear Safety Analysis Reports*, April 1992.

4. *Hazard and Barrier Analysis Guide*, available from Richard Trevillian, (301) 903-3074.

KEYWORDS: uranium, criticality, violation

FUNCTIONAL AREAS: nuclear criticality safety, materials handling/storage